PHYSIOCHEMICAL MEASUREMENT AND OPTICAL CHARACTERISITCS OF BOUNDARY LAYER AEROSOL FIELDS

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LONG TERM GOALS

Establish an improved understanding of the properties and factors that control the structure of near surface marine aerosol fields and their optical properties. Our focus is on the production, transformation and optical properties of the aerosol with particular interest in sea-salt and submicrometer sulfate in a coastal setting with and without breaking waves. The results will be used to help refine the NAVY NOVAM, NAM etc. aerosol models.

SCIENTIFIC OBJECTIVE

We will characterize the size-spectra of submicron and supermicron particles from braking waves and bubble bursting. We will aslo use rapid response coordinated aerosol measurements from a portable laboratory and aircraft in conjunction with our UH lidar (Shiv Sharma - ONR N00014-96-1-0317) to characterize properties and variability in 3-dimensional aerosol fields and link them to process that can be modeled. Both in-situ aircraft and time-sequence coastal data will be used to generate statistics of the atmospheric aerosol and its size dependent properties that can be related to the statistics of their distribution and optical effects as detected by the lidar. When present, we will use the sulfate plume emitted from Kiluaea volcano as a surrogate for continental pollution aerosol since the concentrations and size distributions are similar. Additional specific experiments to characterize individual wave breaking events will be carried out in order to quantify the perturbations to the full aerosol size distribution and their optical effects that arise from this process.

APPROACH

Rapid-response optical counting and sizing instrumentation coupled with thermal decomposition is used to obtain "dry" size-resolved information on the aerosol volatility and to infer the relative concentrations of the various species (eg. sea-salt, sulfate) present in the aerosol. A custom Tandem Radial Differential Mobility Analyzer (TRDMA) and Laser Optical Particle Counter

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will be combined to yield the complete size distribution captured from individual braking waves using our custom LAG (lagged aerosol grab)chamber. The LAG chamber will sample individual wave-plumes by triggering collection via a rapid response particle counter. This will provide specific information on coastal wave submicromenter particle production (dry sizes). Laboratory investigations of the bubble bursting mechanism will also be carried out with similar instrumentation.

Continuous measurements of ambient concentrations and variability will be carried out with a Forward Scattering Spectrometer Probe (custom FSSP-300x; size distribution 0.3-20um or 0.5-50um)and a PVM-100 (Gerber Probe, effective particle diameter) and Nephelometer (TSI 3-wavelength light scattering) in order to develop statistical characterization of particle fields under various conditions that can be compared to concurrent lidar structure measurements. These instruements will be co-located with the lidar facility at Makai Pier on the windard coast of Oahu in order to provided simultaneous measurements during onshore flow. A light aircraft (Cessna 172) package will also be assembled with a mini-nephelometer (Radiance Research), nuclei counter (TSI 3760), mini optical particle counter (Met 1) and PVM-100 to intercompare directly with lidar vewrtical profiles and 3-D field data.

TASKS COMPLETED OR TECHNICAL ACCOMPLISHMENTS

* A light weight instrument package suitable for deployment on a Cessna 172 was tested and deployed on the north coast of the Big Island of Hawaii. This was refined and updated to allow GPS capability and computer datalogging. A paper was presented at the American Association for Aerosol Research meeting in Orlando during October 1996 (Litchy and Clarke).
* An FSSP-300 from Particle Measurement Systems was delivered and tested with custom hardware/software modifications provided by Droplet Measurement Technologies (Darrell Baumgardner). Field testing revealed some shortcomings and and the instrument is being udated with the second revision hardware of its custom selectable dual range capability extending performance from a lower limit of 0.5 to 0.3um.
* Upgrading and preparation of our coastal field site (Bellows Air Force Base) was completed with new power, laboratory, access and security measures.
* Preliminary studies of breaking waves were carried out at the Bellows tower using our DMA and TDMA systems and presentation of these results were presented at the Fall AGU meeting in San Francisco (Shulman and Clarke). We also examined ACE-1 aerosol vertical profiles for sea-salt characterisitcs in the clean marine boundary layer.
* Our field research laboratory was instrumented and operated at the Makai pier alongside the Lidar facility (S. Sharma) and concurrent measurments were made and intercompared with lidar data. These are being prepared for presentation at the 1997 AGU Fall meeting in San Francisco.

RESULTS

* Demonstrated that a portable aerosol microphysics package could be successfully deployed as a light aircraft Cessna 172 package.
* Demonstrated that particle production from breaking waves can produce sizes as small as 10nm diameter. At our Hawaii site some of these were sea-salt in nature while the smallest

particles appeared to have characteristics similar to organics.

* Laboratory studies confirmed that individual bubbles in the near 2mm size range tend to produce the greatest number of droplets per bubble. Data also suggested that as bubbles combine to form foam the droplets produced can increase in both size and number.

* Established the separate vertical gradients for coarse and fine particle (<1.0um) sea-salt in the marine boundary layer from our ACE-1 data. Also, demonstrated the development of a the vertical profile in sea-salt for an air mass during Lagrangian advection during ACE-1.

IMPACT

We expect to establish quantitative links to lidar backscatter that can be applied generally to the interpretation of lidar data in coastal regions. We also plan on establishing statistical characterization of coastal aerosol fields that can be used to model aerosol extinction in this environment. Direct microphysical characterization of breaking wave particle production under various wind speeds etc. are expected to provide predictive links to the observed structure of the aerosol field that can be included in model parameterizations of the coastal and near surface aerosol.

RELATION TO OTHER PROJECTS

Work under this proposal has been co-ordinated with lidar backscatter measurements proposed by Dr. S. Sharma et al. under ONR grant N00014-96-1-0317. The breaking wave microphysics study was prompted by initial observations in our Christmas Island Experiment under ONR-N00014-92-j-1388. The light aircraft package was originally developed as a prototype under NASA grant NAGW-3766 and is being expanded and improved for activities under this grant. The ACE1 sea-salt data was also derived from work done under NAGW-3766.